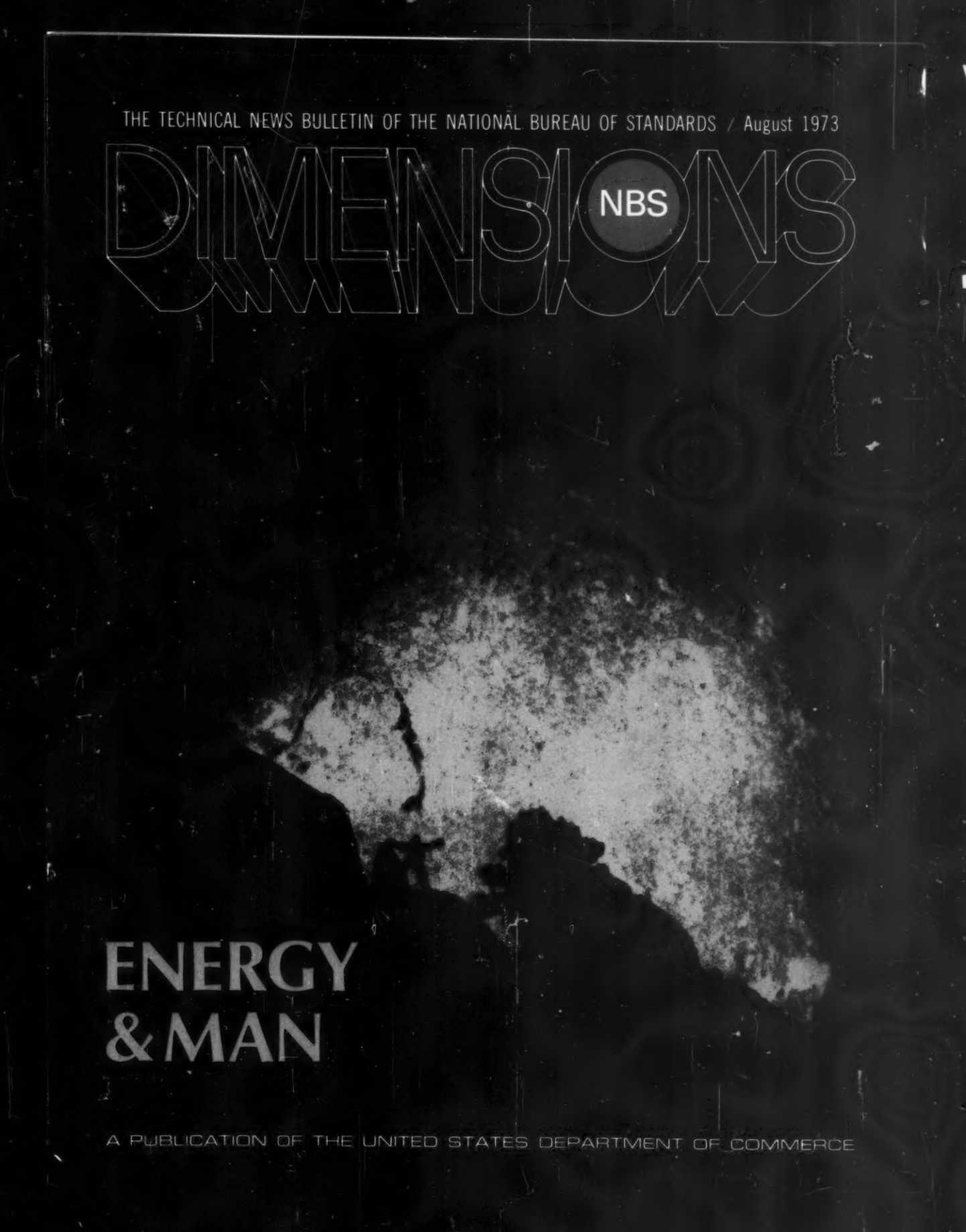
THE TECHNICAL NEWS BULLETIN OF THE NATIONAL BUREAU OF STANDARDS / August 1973

# DIMENSIONS NBS



# ENERGY & MAN

A PUBLICATION OF THE UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

# DIMENSIONS NBS

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*Man, with arms outstretched against the glowing sun, dramatically symbolizes the origin of most of our planet's energy. This issue of DIMENSIONS / NBS is devoted primarily to describing the Bureau's role in solving today's energy problems. (Photo was taken through the solar telescope at the Commerce Department's National Oceanographic and Atmospheric Administration Observatory in Boulder, Colo.)*



The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

The Institute for Basic Standards

The Institute for Materials Research

The Institute for Applied Technology

The Institute for Computer Sciences and Technology

Center for Radiation Research

Center for Building Technology

Center for Consumer Product Safety

Formerly the TECHNICAL NEWS BULLETIN of the National Bureau of Standards.

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# to our readers

SINCE ITS FOUNDING at the turn of the century, the National Bureau of Standards has communicated the results of its work to the public.

Initially, that public was largely the academic, scientific, engineering, and technical communities, and they are still in the forefront.

In the last decades, however, a new pattern emerged. As the Bureau became more directly involved in immediate national problems and goals, its work also began to interest additional, broader audiences.

At present our audience includes not only practitioners of the professional disciplines but also—very literally—the people who live down the block: the consumer, the student, the housewife, the homeowner. They are interested in our consumer-oriented publications, what we can contribute to an understanding of the metric system, our work on flammable fabric standards, what we are doing about the energy problem.

To speak to this multiform audience, to report what we are doing here, we have rethought and restructured our monthly publication.

First, the title change. So many, and such varied, activities are proceeding at the Bureau that it is truly a many faceted organization. We think the new title, *DIMENSIONS/NBS*, reflects this multidiscipline activity.

Second, the content. We will attempt to report more broadly on the Bureau's activities, especially those of current interest to the scientific and general public. You'll note, for example, that this issue devotes much space to NBS activities in the area of energy. Charts, diagrams, and photographs will be used extensively wherever they will contribute to clarity and understanding. Our format will be as attractive and functional as we can make it.

The National Bureau of Standards, the Nation's laboratory, is a vital national resource. Its work is important to you, and we want to tell you about it.

Richard W. Roberts

RICHARD W. ROBERTS
*Director, National Bureau of Standards*

# ENERGY AND NBS

The energy shortage is real, and is likely to get worse in the near future unless we act quickly. Fortunately, while we explore new avenues of supply, there are a number of steps that we can take to conserve energy, and there is an agency, the National Bureau of Standards, that has a lead role to play in implementing these steps.

President Nixon, in his energy message of April 18, 1973, specifically cited NBS measurements as the cornerstone for the conservation of energy in buildings. The savings could be enormous, as building services use 33 percent of our energy consumption, and 40 percent of this energy could be conserved with improved thermal design and construction practices. The President also directed the Department of Commerce to develop a system of efficiency labeling for appliances, a task to which NBS is now applying its technical know-how. That the President turned to NBS is no accident, as the Bureau has been involved in various aspects of the energy question almost from its founding in 1901.

On May 15 NBS conducted a day-long seminar on energy at which 30 different topics were explored by Bureau experts. (For a copy of the program, including an abstract of each paper, write to the Office of Information Activities, NBS, Washington, D.C. 20234). These papers, grouped under the headings Energy Conservation, Future Power Sources, Materials, and Transmission, are indicative of the deep NBS involvement in the energy problem.

On June 19 the Bureau's Center for Building Technology, responding to an urgent request from the National Conference of States on Buildings Codes and Standards, cooperated with NCSBCS in presenting an emergency workshop on energy conservation in buildings. At this meeting, which is summarized in detail in an article in this issue, the problem of conserving energy in buildings was outlined, steps for conservation were detailed, and mechanisms for implementation were explored.

Earlier this summer, Dr. Richard W. Roberts, the Bureau's Director, testified before the House of Representatives, and Dr. Betsy Ancker-Johnson, Assistant Secretary of Commerce for Science and Technology, testified before the Senate, on the energy shortage. They summarized Bureau programs in

- conserving energy in buildings;
- exploration of the usefulness of solar heating as an adjunct to conventional building heating systems;
- elimination of waste in industrial processes such as cement and glass making;
- materials problems in coal gasification;
- ceramics for high-temperature turbines;
- measurements required for fusion research; and
- voluntary labeling of appliances.

The articles that follow are designed to give a quick overview of NBS activities in the energy area. As specific objectives are attained they will be reported in the technical literature, brought to public attention if appropriate, and reported in this publication.

In September the Bureau will participate in the 3d Urban Technology Conference in Boston. Dr. Roberts will present the keynote address at the Energy Session, Charles Berg and P. R. Achenbach will present papers, and a Bureau exhibit on energy will be shown.

# ENERGY CONSERVATION IN BUILDINGS

Engineers at NBS have reliably estimated that 40 percent or more of the energy used for heating and air conditioning of buildings could be saved. Building practices of the past, based on low-first-cost objectives, have led to an estimated annual waste of energy equivalent to about 456 million tons of coal, or 65 billion gallons of oil, or 9 trillion cubic feet of natural gas.

NBS has had a concern with the measurement of building performance since its founding in 1901 and, today, the Center for Building Technology—drawing on the resources of the entire Bureau—has 15 major projects bearing on energy conservation, including such laboratory and field studies as:

- Computer prediction of thermal performance in buildings
- Planned ventilation of buildings
- Modular-sized integrated utility systems
- Total energy systems for multibuilding complexes
- Thermal physical properties of insulation and other building materials
- Solar heating
- Thermal efficiency of equipment.

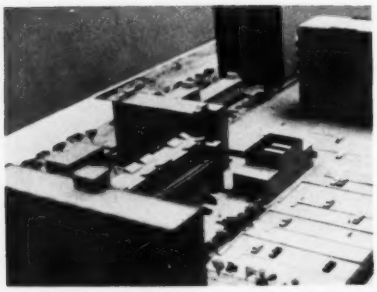
*A cross section of participants at the Joint Emergency Workshop on Energy Conservation in Buildings held at the Department of Commerce June 19, 1973.*

That NBS has been in the forefront of the growing move to conserve energy in buildings is demonstrated by two Bureau booklets released through the Office of Consumer Affairs in 1971: 558,000 copies of "7 Ways to Reduce Fuel Consumption in Household Heating...through energy conservation,"[1] and 274,000 copies of "11 Ways to Reduce Energy Consumption and Increase Comfort in Household Cooling" have been distributed.[2]

## ENERGY SEMINAR

At the NBS In Action Seminar held at the Bureau on May 15, strong emphasis was laid on energy conservation in buildings.

- Keynote speaker Dr. C. A. Berg, Deputy Director of the Institute for Applied Technology, estimated that as much as 25 percent of the Nation's fuel could be conserved by applying available improvements to building equipment and industrial practices.
- Dr. Tamami Kusuda of the Thermal Engineering Systems Section reported on a computerized building-system analysis which models daily heating and cooling cycles, taking into account thermal storage and energy requirements. The model has been correlated with experiments on two buildings of different construction.
- Frank J. Powell, Chief of the Thermal Engineering Systems Section, reported on detailed modeling of an eight-story Federal Office Building in Manchester, N.H.
- Dr. Jack E. Snell, Chief of Building Service Systems, spoke on integrated utility systems which utilize "throw-away" heat energy for space heating, domestic hot water production, and absorption air conditioning. Dr. Snell noted that 60 to 70 percent of the fuel energy used to



*Model of Jersey City Site of NBS Total Energy Systems Evaluation Project, sponsored by the Department of Housing and Urban Development.*

generate electricity at a remote plant is wasted and rejected to the natural environment. In contrast, by generating electricity onsite, roughly half the heat normally rejected can be recovered and used for heating, hot water production, and air conditioning. Measurements to evaluate the systems' efficiencies and economies are being made at a HUD BREAKTHROUGH site in Jersey City.

### NCSBCS WORKSHOP

At just about the time of the Energy Seminar, the National Conference of States on Building Codes and Standards (NCSBCS), a working partner of the Bureau since 1967, asked the Bureau to set up an emergency workshop as a forum for determining ways for State and local governments to cope with increasing demands on energy fuels. The workshop was held on June 19 at the U.S. Department of Commerce.

In complimenting NCSBCS and NBS officials, Dr. Roberts said, "the ability to call and organize this workshop in one month's time is a vivid demonstration of the partnership's state of readiness."

Keynote speaker Dr. Kenneth Lay, Deputy Under Secretary of Interior (Energy), cited an Office of Emergency Preparedness estimate that by 1980 the United States could save about a third of the energy consumed by employing good conservation practices. He congratulated NCSBCS and NBS for studying "this most promising policy option."

Morning Session Chairman Dr. Jack E. Snell, of the NBS Building Environment Division, underlined the seriousness of the issue by citing that about a third of the Nation's energy is used in buildings and that over 80 percent of this energy is used in heating and air conditioning. The waste of 40 percent of the heating and air conditioning energy is caused by building design, construction practices, and uses to which buildings are put, Dr. Snell said.

Drs. James E. Hill and Tamami Kusuda, and Clinton W. Phillips and Frank J. Powell—all of the NBS Center for Building Technology—identified more than 100 actions to reduce the energy pinch, including:

•**Short term actions**—voluntary and regulatory—that can save energy without additional expenditures:

*Winter Heating*

Set your thermostat lower

Close off rooms not used and turn off heat

On winter days let the sunshine in—pull shades at night

Reduce air leakage and ventilation

Be careful about open windows and doors

Reduce temperature in public spaces, lobbies, etc.

Institute rigorous schedules for planned operation of ventilation

Wear heavier clothing

Maintain an efficient heating plant

Turn off-turn down lights and electric appliances except when needed

Concentrate evening work or meetings in a single heating zone

*Summer Cooling*

Turn off unneeded systems

Set thermostat at upper comfort margin, 80 °F

Turn off unneeded lights

Use improved lighting practices

Minimize use of heat producing devices

Use stove/oven ventilation hoods

Wear lightweight clothing

Reduce excessive ventilation

Minimize solar loads

Use cool outside air for cooling

Keep heat transfer surfaces clean

Clean or replace air filters regularly

Lubricate and service unit regularly

•**Short term actions** requiring modest expenditures for readily obtainable materials and equipment:

*Winter Heating*

Add a clock thermostat

Add insulation, as much as feasible

Add insulating glass, or storm windows and doors

Caulk and seal around windows, doors and other openings

Insulate heating ducts, and seal against air leakage into nonheated spaces (attics, crawl spaces)

Maintain heating equipment—clean heat transfer surfaces

Install heat recovery and conservation devices

Install automatic pilot light

Adjust ventilation system

Avoid use of portable electric heaters by improving main heating system

Replace defective or inefficient heating systems with systems of higher efficiency

Modify systems for zone control using systems of higher efficiency

Provide means to transfer heat from the core of a large building to the cool periphery needing heat

Install automatic door closers

*Summer Cooling*

Insulate or add insulation

Use insulating glass

Install solar shading

Insulate and ventilate attics

Install zone controls

Reduce lighting loads

Install automatic pilots

Reduce unneeded ventilation
Reduce infiltration
Eliminate "new energy" reheat systems
Install high-efficiency replacements
Install short-term heat storage
Install interlocks between heating and cooling
Install heat recovering devices
Insulate and seal ducts
Use "spot" cooling
Use individual metered systems
Use cool outside air for cooling
Establish effective maintenance.

Also discussed were ways of identifying or developing performance standards and potentials for conservation of energy in insulation, placement of windows, lighting, appliances, and hot water; and in design, construction, and operation of buildings.

Afternoon session Chairman K. C. Henke, Chairman of the NCSBCS Standards and Evaluation Committee, and delegate to the Conference from the State of Iowa, focused on ways to implement alternatives presented in the morning session. Paul R. Achenbach, Chief of the NBS Building Environment Division, discussed "Available Options for Implementation and Concepts for Design Standards," Mr. Henke summarized a survey of State Actions, and J. Stein, Vice President of Tishman Research Corporation, discussed "Energy Use Criteria in Building Standards and Regulations."

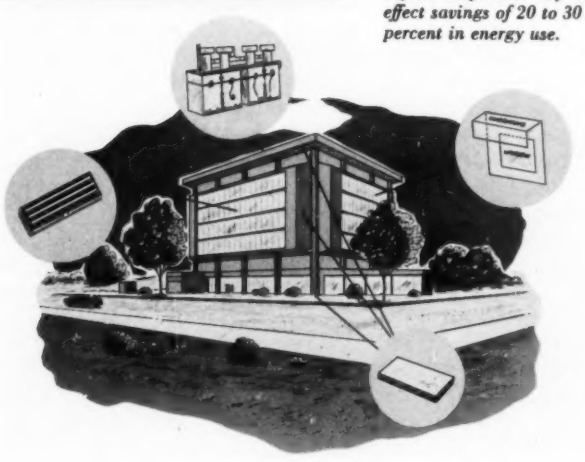
Other speakers were Walter A. Meissen, Assistant Commissioner for Construction, Public Buildings Service, GSA, and Bernard E. Cabelus, National Chairman of NCSBCS. Also attending the workshop were construction industry representatives and government scientists concerned with energy conservation. Participants were provided with 154-page copies of the NBS presentation.[3]

PERCENT FUEL SAVINGS WITH NIGHT THERMOSTAT SETBACK FROM 75° F

SETBACK 8 HRS., 10 P.M. TO 6 A.M.

| CITY | SETBACK | SETBACK | SETBACK |
|---|---|---|---|
| ATLANTA | 11 | 13 | 15 |
| BOSTON | 7 | 9 | 11 |
| BUFFALO | 6 | 8 | 10 |
| CHICAGO | 7 | 9 | 11 |
| CINCINNATI | 8 | 10 | 12 |
| CLEVELAND | 8 | 10 | 12 |
| DALLAS | 11 | 13 | 15 |
| DENVER | 7 | 9 | 11 |
| DES MOINES | 7 | 9 | 11 |
| DETROIT | 7 | 9 | 11 |
| KANSAS CITY | 8 | 10 | 12 |
| LOS ANGELES | 12 | 14 | 16 |
| LOUISVILLE | 9 | 11 | 13 |
| MILWAUKEE | 6 | 8 | 10 |
| MINNEAPOLIS | 8 | 10 | 12 |
| NEW YORK CITY | 8 | 10 | 12 |
| OMAHA | 7 | 9 | 11 |
| PHILADELPHIA | 8 | 10 | 12 |
| PITTSBURGH | 7 | 9 | 11 |
| PORTLAND | 9 | 11 | 13 |
| SALT LAKE CITY | 7 | 9 | 11 |
| SAN FRANCISCO | 10 | 12 | 14 |
| ST. LOUIS | 8 | 10 | 12 |
| SEATTLE | 8 | 10 | 12 |
| WASHINGTON, D.C. | 9 | 11 | 13 |

*Computer calculations show the 24-hour fuel savings (by percentage) per day for 25 cities when the thermostat is lowered 5, 7 1/2, and 10 °F per night. The table indicates that though percentages of fuel savings are higher in warmer climates, total savings are greater in colder regions where more fuel is used. (Minneapolis-Honeywell Data, 1973.)*



*A sketch of GSA Federal Office Building in Manchester, N.H., showing energy conservation aspects emphasized by NBS to effect savings of 20 to 30 percent in energy use.*

## A TEST BUILDING

Notable among upcoming activities is an eight-story General Services Administration (GSA) building to be constructed in 1974, discussed at the Energy Seminar by Frank J. Powell.

As a result of the NBS/GSA Roundtable on Energy Conservation in Public Buildings held May 23-24, 1972, the General Services Administration decided to design and construct the building in Manchester, N.H., and to determine by field measurement the energy conservation achieved by various design concepts incorporated in the building. The ultimate results would be incorporated in commercial as well as public buildings.

The Bureau was asked by GSA to assist the engineering firm of Dubin, Mindell, Bloom and Associates of New York by using the heating and cooling load analysis program to predict the energy demand of the building as a function of a variety of building design parameters. GSA also asked NBS to look at the lighting levels of the building, and to provide information on small multiple and large single boilers.

Bureau personnel specifically looked at the shape of the building; amount and placement of insulation in the roof, the walls, and the floor between the underground garage and the first floor; and the shape

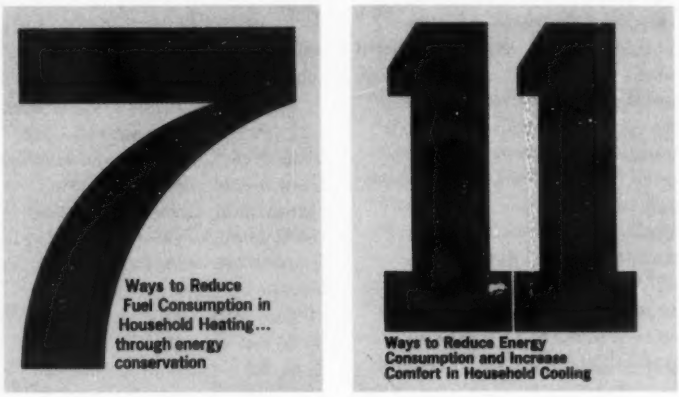
and size of windows (including potential window overhangs).

NBS studies indicate expected savings of 33 percent in yearly energy requirements. The actual overall savings achieved, and the contribution of each design feature to the total, will be determined by field measurement.

[1] For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Stock Number 0303-01086—Price 35 cents.

[2] For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Stock Number 0303-0876—Price 30 cents.

[3] Technical Options for Energy Conservation in Buildings, NBS Technical Note 789. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. SD Catalog No. C13.46:789 - Price $2.35, prepared for Joint Emergency Workshop on Energy Conservation in Buildings, June 19, 1973.




**As a public service, single copies of these energy conservation booklets will be supplied upon request to: National Bureau of Standards, Att: Editor, DIMENSIONS, NBS, Washington, D.C. 20234 (Multiple copies may be purchased from the Superintendent of Documents. See footnoted order information.)**

# Household Appliance Energy Labels

One innovative approach to the Nation's energy conservation program is a plan to develop voluntary labeling of major home appliances to alert consumers about the energy consumption of products.

NBS has taken the lead in this program which was assigned to the Department of Commerce by President Nixon in his April 18 Energy Message. The President directed that the Department

> develop a voluntary system of energy-efficiency labels for major home appliances. These labels should provide data on energy use as well as a rating comparing the product's efficiency to other similar products.

On June 5, Secretary of Commerce Frederick B. Dent had printed in the *Federal Register* a proposal outlining the scope and nature of the program.

"The Department of Commerce's Voluntary Labeling Program for Energy Conservation is designed to help the consumer make more intelligent buying choices, as well as help each individual and the Nation save energy," Secretary Dent said. "For example, there are over 1,000 different window air conditioners on the market. This program should help the buyer decide, in advance, which unit, within each range of price and capacity, is most efficient and most desirable for his needs."

Comments on the proposal were expected no later than August 5.

Earlier this summer, Commerce's Assistant Secretary for Science and Technology, Dr. Betsy Ancker-Johnson, described the plan—along with other energy programs of NBS and the Department—to the new U.S. Senate Special Subcommittee on Science, Technology and Commerce. NBS Director Dr. Richard W. Roberts did the same before a joint hearing by the House Science and Astronautics Subcommittee on Energy and the Government Operations Subcommittee on Conservation and Natural Resources. They each pointed out that the proposed procedures, developed cooperatively by Dr. Melvin Meyerson of the new NBS Consumer Product Safety Center, Department officials, the Council on Environmental Quality, and the U.S. Environmental Protection Agency, would cover room and central air conditioners, household refrigerators and freezers, clothes washers and dryers, dishwashers, kitchen ranges, and water heaters. Other appliances may be covered under future proposals.

The program is expected not only to help the consumer directly in selecting those appliances which could effect savings in energy consumption, but indirectly by encouraging manufacturers to use new technologies to produce more energy-efficient products in competition in the marketplace.

| ENERGY CONSUMPTION IN THE U.S. BY END USE | |
|---|---|
| RESIDENTIAL | 19.2% |
| COMMERCIAL | 14.4% |
| INDUSTRIAL | 41.2% |
| TRANSPORTATION | 25.2% |
| | 100.0% |

# ENERGY GENERATION AND TRANSMISSION

NBS is working on a number of projects dealing with the generation and transmission of energy—a vital need for the future progress and development of the United States.

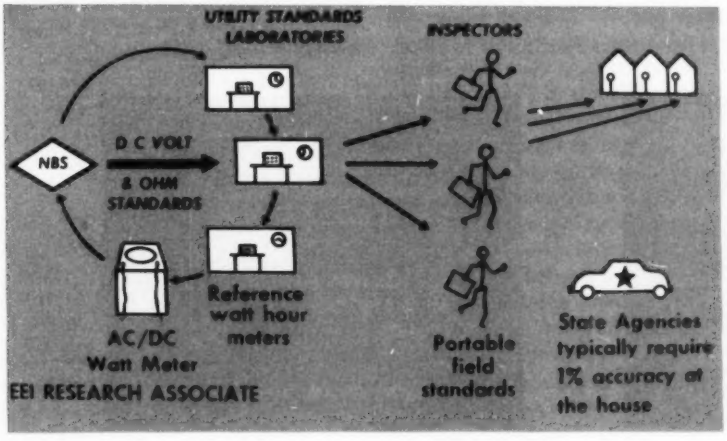
Work is being done in the development of a new electrical system for measuring power losses in those large high-voltage shunt reactors which are used to "tune out" transmission line capacitances. Studies are also underway to eliminate electrode motion under the stress of high-voltage electric fields, stresses associated with energy loss and breakdown in dielectric liquids, and to increase the use of timing signals to reduce area control error in power network interties across the United States.

Electron technology is becoming increasingly more important in helping to solve problems dealing with energy. The optimization of large-scale semiconductor power devices are expected to find increased uses in electrical controls where economy, efficiency, and reliability are key considerations. The use of mass transit is one of the important ways of making more efficient use of our Nation's energy resources. Reliable operation is extremely important to ensure the safety and public acceptance of such systems. In order to transmit the large amounts of power that will be necessary in the future, increased use of dc transmission lines and links will be needed that will require semiconductor devices. Two problems that will have to be overcome before such powerful devices can be put to use are the limitations caused by localized hot-spot formation in p-n junctions and by the attainable average junction temperature.

Important work is being done on a new determination of the $^{10}B(n\alpha)^{7}$ branching ratio, a cross-section frequently used in the design and testing of nuclear reactors. Work also continues on developing standard and reference fast neutron fields to help characterize the neutron economics of reactors. Errors in total neutron cross-section data can result in pronounced effects on shielding problems and personnel safety.

Strong Bureau efforts are being devoted to measurement needed for the development of controlled thermonuclear reactors. Specifically, work is being done to develop stabilized-arc and pulsed-plasma sources for spectra of ionized gases at high temperatures. Of particular interest are the theoretical extensions of spectroscopic regularities along isoelectronic sequences of atoms to obtain predictions of the high-ionization spectra encountered

*Cooperation between NBS and Electric Utilities assures accurate metering for millions of households.*



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in plasma fusion devices. Radiometric studies are being made in such areas as calibrations for extreme ultraviolet diode detectors, standard monochromatic pulse x-ray beams in the energy region from 0.1 to 10 KeV, and in the study of the penetration of high-energy gamma rays through thick layers of neutron shielding. Other programs include spectroscopic research relating to highly ionized heavy atoms, the gathering of atomic data for coal-fired magnetohydrodynamics, compilations of atomic and molecular data, and the prediction of power laser parameters.

NBS at Boulder is involved in developing the potential applications of cryogenics to electrical generators; studies include the efforts of cooling and the use of superconducting windings. NBS scientists at Boulder also are studying properties of hydrogen, a prime candidate for the synthetic fuel of the future.

Other NBS contributions to help solve the energy crunch include a study of the use of coal slag and ash in the direct conversion of chemical to electrical energy, new solid electrolytes for high-energy batteries of fuel cells, the formation of corrosive liquids at high temperatures in coal combustion devices, and the propagation of cracks in those high-temperature ceramics which are typical of the brittle materials now used in high-efficiency power systems.

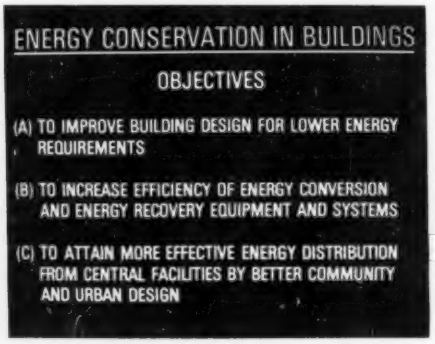
One technique used defines the relationship between the crack propagation rate and the stress intensity factor for hot pressed silicon nitride up to 1400 °C. The data are then used to develop proof test diagrams which give values for the safe working stress levels for this material after proof testing or any other flaw detection procedure.

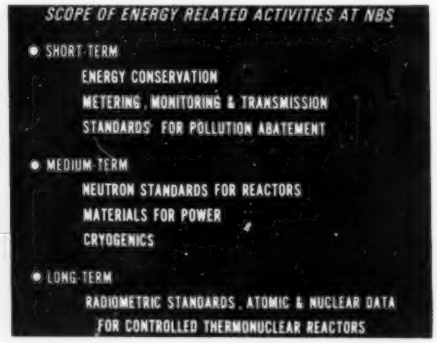
NBS is supporting measurement standards for the future development of more efficient electric lighting. Because of the significant increases in both incandescent and fluorescent efficiencies, illumination levels can now be maintained with the expenditures of 10 percent less power than was previously required. The electricity saved by this increased efficiency can be put to other uses with no decrease in lighting levels. One new method of measurement is based on chopper-stabilized, null-radiometry. This new approach may eventually be employed in solar energy and other radiometry applications. It combines the new technologies of pyroelectric detection and wide-band synchronous amplification with the older technique of electrical self-calibration.

Efforts are also being extended into high-temperature electrical conductivity of channel-coating, electrode, and insulating materials of magnetohydrodynamics (MHD) channels, phase equilibria and crystal growth in alkali tantalates with potential applications to alkali-sulfur batteries, and thermodynamic data as it applies to MHD power systems. Metallurgical studies are underway in the electronic properties for potential MHD electrodes, including transition metal diborides as well as platinum and nickel.

Users and producers of liquefied natural gas, including the American Gas Association, are being helped by programs to develop accurate methods for determining the fuel value of delivered gas mixtures. Research is also being conducted on improving the density determinations and sampling methods for calorimetric analysis.

The purpose of the NBS program in Standard Reference Data is to supply reliable values of physical and chemical properties needed by science and technology. The program operates by retrieving data published throughout the world, subjecting these data to a critical evaluation by experts, and disseminating the values in suitable compilations for various user groups. This data system includes information on energy conservation and transmission including thermodynamic and transport properties related to combustion research, alternative vehicular power plants, battery development, and liquefied natural gas. It also deals with projects in the atomic and molecular areas that contribute to research on controlled thermonuclear fusion, and a proposed compilation dealing with coal gasification.



# LIQUEFIED NATURAL GAS AND NBS*

Imported liquefied natural gas (LNG) is rapidly becoming an important factor in alleviating the current shortage of natural gas in the United States. The Cryogenics Division at the Bureau's Boulder Laboratories is currently involved in a number of programs dealing with LNG and the problems it poses regarding custody transfer. Good measurements of amounts bought and sold are hard to make, yet multimillion dollar transactions in LNG are frequently consummated.

NBS, in cooperation with the gas industry, is studying the problems involved in measuring LNG, and is developing and evaluating new techniques for making the measurements essential to equitable trade.

Over 30 percent of U.S. energy consumed is derived from natural gas. Domestic reserves of natural gas decreased for the first time in 1968, and have continued to do so at an increasing rate since then. While some of the demand for gas can be supplied by alternative fuels, and manufactured gas from coal and other primary sources will be produced in greater quantities, the United States will probably have to greatly increase its imports of natural gas, at least until more domestic reserves can be put into production (at ever increasing cost) and coal gasification and similar processes are perfected.

The only economically feasible way to import gas from overseas is in the form of LNG carried in specially built insulated tankers. Liquefying the gas reduces its volume by a factor of 630, allowing more gas to be carried in each trip than compressed gas cylinders would allow. The gas is liquefied by cooling it to about 112K (−258 °F), hence efficient insulation is essential during transport. The unavoidable boil-off is used to drive the ship on at least part of its journey.

When the ship arrives at a port for unloading into a storage tank, both buyer and seller want to know how much gas is being delivered. Since the cargo's value depends on both its heating value per unit weight or unit volume and on the amount delivered, accurate measurements have to be made of these quantities. And there's the problem. Measuring the heating value of a sample of the gas is not very difficult; these measurements have been made for years on natural gas with satisfactory results. But how does one accurately measure the total quantity of a liquid that boils at 112K (−258 °F).

If the exact capacity of the ship is known, it could be used as a kind of calibrated bucket. But the ship never arrives full, and it usually is not emptied completely (it needs to keep some LNG on board as fuel for the return trip and to keep the tanks cold), so the dimensions of the tanks must be known accurately. The levels of LNG in the tanks must be measured closely at the beginning and end of delivery, and these measurements related to the volume of LNG delivered. Other data must be known also, such as the amount of expansion and contraction of the tanks with changes in temperature, load, etc. All this leaves room for error, as much as $32,000 worth in a $1.6 million load of LNG.

Another method of measuring the delivery is to put a flowmeter in the delivery line between ship and storage tank. Theoretically, this is a more satisfactory solution, being much simpler than using the ship as the measuring device. In actual practice, however, the problem is that there are no proven flowmeters capable of measuring LNG at the high flow rates and extremely low temperatures involved. Existing high-accuracy flowmeters for cryogenic fluids are generally small-scale devices incapable of measuring flows of thousands of gallons per minute, needed to unload a ship in as short a time as possible. As flow rates increase pipe size, friction, and other factors take increasing tolls in accuracy. In addition, the density of the LNG must be determined, as part of the calculation of heating value.

NBS is currently conducting research in all aspects of this custody-transfer problem, developing and evaluating better flowmeters and densitometers, measuring the physical and thermodynamic properties of LNG and its components, and determining the mechanical and thermal properties of materials used to contain and insulate LNG. These studies are supported by grants from the gas industry through the American Gas Association and contracts with the Maritime Administration.

Specific program areas include a literature survey of current information published about LNG, studies of the thermophysical properties of LNG mixtures and pure components down to 89K (−300 °F), and development and evaluation of systems to measure the flow and density of LNG accurately at high flow rates.

*continued on page 192*

*Excerpted from a speech given by D. B. Mann, Chief of the Cryogenic Metrology Section of the NBS Cryogenics Division, at the American Gas Association Distribution Conference May 14, 1973, in Washington, D.C. Proceedings to be published.

# COMPARATIVE

## OF MOTOR VEHICLES OPERATED ON GASOLINE,

NBS has examined the performance of several motor vehicles run on gaseous fuels rather than gasoline. The operational and exhaust emission characteristics of 1/2- and 1-ton trucks run on three different fuels—gasoline, compressed natural gas (CNG), and liquefied petroleum gas (LPG)—were determined for the U.S. Postal Service (USPS).

Emissions of hydrocarbons (HC), carbon monoxide (CO), and the oxides of nitrogen ($NO_x$) were monitored on USPS trucks under a range of environmental and load conditions. Three dual-fuel systems were analyzed and recommendations made on the best settings for spark firing and fuel regulation (for CNG and LPG) to minimize pollutants and to produce acceptable power.

National concern for the quality of the environment led to the establishment of the Clean Air Act of 1970. This Act and its amendments require that strict standards of emission control on automotive engines be met by 1976. This relatively early date practically necessitates that the standards be met by an engine of conventional design rather than by a new approach to automotive power.

As yet, there is no single engine modification with widespread applicability that simultaneously reduces all three pollutants (HC, CO, $NO_x$) to the required amounts. Consequently vigorous attention is being given to possible changes in engine fuel. Modification of the basic gasoline fuel is not considered a promising technique for reducing the pollutants. However, the use of an entirely different fuel seems feasible for some applications.

The primary pollutants of the internal combustion engines are CO, $NO_x$, and unburned HC. Gaseous fuels (so designated because they are in the gaseous state before they are carbureted into the engine) such as CNG and LPG reduce emissions through more complete combustion.

Gasoline must first be vaporized and then mixed with the correct amount of air. Gaseous fuel only needs to be mixed with the proper amount of air; thus the carburetion

*David Ward makes engine adjustments during an LPG test on the 1/2-ton truck. Recommendations were made on the best settings for spark firing and fuel regulation to minimize pollutants and produce acceptable power.*

*John Grimes controls vehicle running conditions from an adjoining room.*

# E PERFORMANCE

## IE, COMPRESSED NATURAL GAS, AND PROPANE

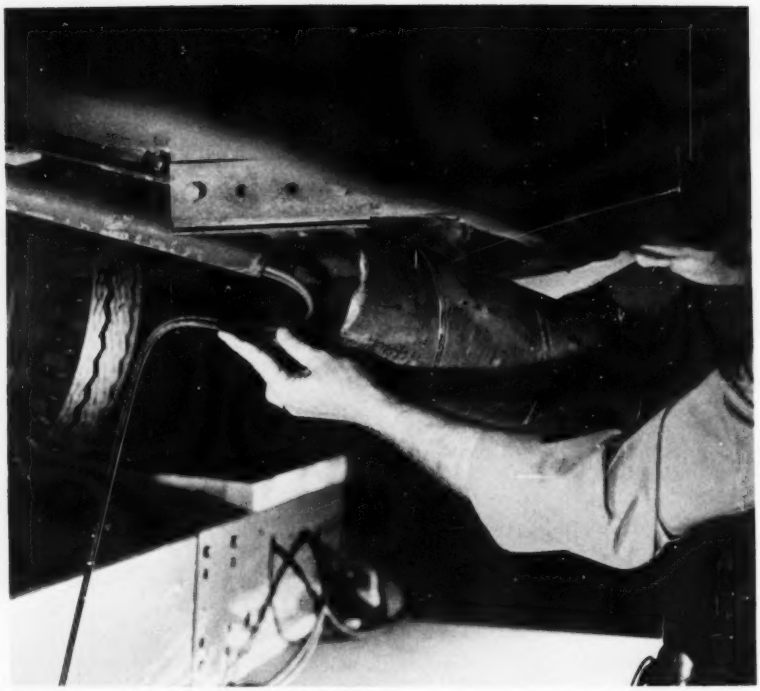
can be simpler and more accurate, and the mixing of air and fuel more thorough. There is no liquid in the induction system to upset the mixture or to pass through the engine unburned. It is this high degree of carburetion control and the simple chemical composition of gaseous fuels that make the operation of gaseous fuel systems clean.

The NBS testing program was conducted by Drs. David Didion and James Hill of the Bureau's Thermal Engineering Systems Section. A 1/2-ton and a 1-ton truck were put into an environmental chamber so that the rear wheels rested on a chassis dynamometer. In the series of tests, ambient temperature was controlled at various levels between 0 °F and 110 °F and a range of spark advance setting and air-fuel ratios were used on the engines. The vehicles were run at various dynamometer loads and simulated speeds ranging from idling to 50 miles per hour. They were equipped with a total of three commercially available dual-fuel systems (systems designed to allow the vehicles to be run on either gasoline or a gaseous fuel; the specific fuel is selected by a switch on the dashboard).

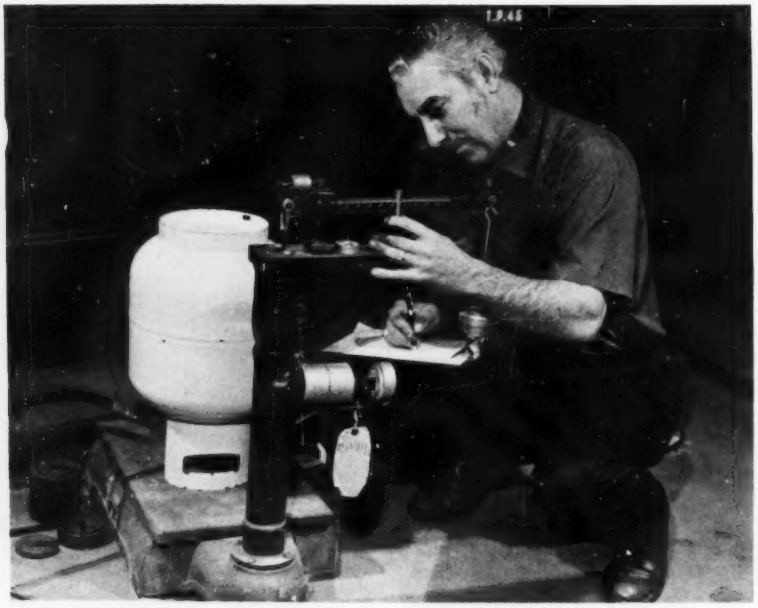
HC, CO, and $NO_x$ emissions were measured by withdrawing air samples from the exhaust pipe, bubbling them through glass traps containing water to condense excess water vapor, and then passing

*turn page*

*The rear wheels of the 1/2-ton truck are shown mounted on a chassis dynamometer in an environmental chamber. Vehicles were run at various simulated loads and speeds from idling to 50 mph.*



*The exhaust probe is placed in position by Boyd Shomaker. Emission measurements were made for HC, CO, $NO_x$, and $CO^2$.*



*The rate of LPG used by the 1/2-ton truck is monitored by Bud Windell of the U.S. Postal Service.*

**PERFORMANCE** *continued*

them to an infrared beam detector. $CO_2$ was also measured so that the air-fuel ratio could be determined for any particular test by exhaust gas analysis.

For example, it was found that the pollutant levels of the 1/2-ton truck operating in the range 0-50 mph at 30 horsepower and 0-110 °F ambient temperatures could be kept below the following values under steady running conditions.

| Pollutant | Fuel | | |
|---|---|---|---|
| | Gasoline | CNG | LPG |
| $NO_x$ (ppm) | 1700 | 300 | 500 |
| HC (ppm) | 190 | 50 | 190 |
| CO (%) | 1.10 | 0.10 | 0.13 |

As with any new system, there are some disadvantages. Today's vehicles must be converted in order to burn gaseous fuels, and the fuels, especially CNG, are not readily available in service stations. Therefore, special provisions must be made to obtain and store the fuel. These factors presently restrict gaseous fuels to use in fleet vehicles. Fleet operators often have their own shops and mechanics who can be trained to convert the vehicles and maintain them. Also, many fleet operators buy their fuel in bulk and have their own refueling facilities.

The Federal Government operates between 300,000 and 400,000 vehicles—excellent potential candidates for gaseous fuels. Consequently, in October 1969 the General Services Administration (GSA) launched the Federal Government's first fleet of CNG-powered test vehicles. At that time 12 vehicles in the Los Angeles area were converted to a CNG-gasoline dual-fuel system. Today approximately 1,500 GSA vehicles operate with such a system. In addition, the Postal Service is operating a fleet of approximately 50 vehicles in the same manner and is presently considering expansion of their operation.

# Three States Receive Weights and Measures Standards

*Harold Wollin of NBS (right) presents Governor David Hall of Oklahoma with a plaque commemorating the presentation of new weights and measures to the State.*

*A portion of the 95-piece set of weights, measures, and weighing instruments, given to the States through the NBS program.*

Indiana, Oklahoma, and Florida were the 38th, 39th, and 40th States to receive new sets of weights and measures under an NBS program to provide new weights and measures standards to the 50 States.

Governor Otis R. Bowen was presented a new set of weights and measures for Indiana by Harold W. Wollin, Acting Chief of the Office of Weights and Measures, and Myron G. Domsitz, Deputy Director of the Institute for Applied Technology, on June 8. The ceremony was held at the Division of Weights and Measures, State Board of Health, in Indianapolis with William T. Paynter, Indiana State Health Commissioner, representing that Department.

Governor David Hall accepted the new standards for the State of Oklahoma at a ceremony in Oklahoma City on June 14. The presentation was made by Mr. Wollin of NBS at the State capitol. Billy Ray Gowdy, President of the State Board of Agriculture, officiated.

On August 21, 1973, Dr. Richard W. Roberts, NBS Director, presented a new set of weights and measures to Governor Rubin Askew for the State of Florida.

The standards are being provided to about 10 States a year until all State standards are modernized. Many of the standards and instruments used until now by the States in weights and measures were provided by the Federal Government more than 100 years ago. The new standards are much more scientifically and technologically accurate due to long-term programs at NBS and similar institutions throughout the world.

Included in the 95-piece set of weights, measures, and weighing instruments are standards in both the U.S. customary system and the metric system. Each new set includes standards of mass (weight), length, and volume and the necessary laboratory instruments, including high-precision balances, to meet State weights and measures requirements.

Each set costs NBS about $80,000, including calibration, installation, and training of laboratory personnel. Each State contributes new or expanded laboratory facilities and qualified personnel.

## STANDARDS ISSUED BY NBS

1. Sixty-seven mass standards (metric and avoirdupois) 30 kilograms to 1 milligram and 50 pounds to 0.000001 pound of 8.0 g/cm$^3$ stainless steel.
2. Two 500-pound stainless steel type 303, stacking weights.
3. One 25-foot, 7-meter precision steel tape with engraved graduations.
4. One 100-foot, 30-meter steel tape.
5. One 16-foot, 5-meter stainless steel length bench, precision microscope, tension weights, and other accessories.
6. One 18-inch steel rule graduated in hundredths, sixty-fourths, thirty-seconds, and sixteenths of an inch.
7. Sixteen volume standards including 12 pipets and 4 burets, 5 liters to 1 milliliter and 1 gallon to 1 minim.
8. One 5-gallon, stainless steel volumetric standard with slicker plate.
9. One 100-gram capacity, single-pan, semi-automatic precision balance with 8.0 g/cm$^3$ stainless steel built-in weights.
10. One 1-kilogram capacity, single-pan, semi-automatic precision balance with 8.0 g/cm$^3$ stainless steel built-in weights.
11. One 3-kilogram capacity, single-pan precision balance.
12. One 30-kilogram capacity, single-pan precision balance.
13. One 5000-pound capacity, equal-arm precision balance.

**GAS** *continued*

The goal is to promote confidence between buyer and seller in the LNG marketplace. Confidence depends on each party having equal understanding of the definitions of price, quantity, and quality of goods sold. Standardized methods and equipment for measuring LNG properties and quantities are needed to promote this sense of confidence so essential to long-term commercial operations.

### Current Awareness in Cryogenics

On a regular basis the staff of NBS Boulder's Cryogenic Data Center reviews over 300 technical periodicals and 26 abstract services, including a number of foreign publications. These are reported in the Center's weekly publication, titled the Current Awareness Service.

The scope of this publication is quite broad. It covers the entire field of cryogenics, including liquefied natural gas. The acceptance achieved by this literature research program is indicated by the fact that it presently has over 500 subscribers, including many American Gas Association member companies. The articles identified in each week's issue are entered in the Center's computerized permanent information retrieval system.

The overall objective of the Cryogenic Data Center is to serve as a single source of information on the physical and chemical properties of cryogenic materials. Such a unified data source would help achieve a more accurate profile of cryogenics throughout the world.

# ATOMIC DATA AID U.S. FUSION EFFORTS

Dr. Wolfgang L. Wiese of the Plasma Spectroscopy Section and his fellow scientists at NBS are working intently on providing basic atomic radiation data that are essential to the diagnostics needed in thermonuclear fusion research. Although fusion research *per se* is not done at NBS, the radiation work is necessary to the understanding of high-energy plasmas.

Wiese and his coworkers have been working particularly on determining atomic transition probabilities needed for measurements of plasma temperature and impurity concentrations. The need for these data exists for those elements found as impurities in the deuterium fuel (e.g., nitrogen, carbon, and oxygen) as well as those elements used in the construction of the plasma vessels (e.g., iron, tungsten, titanium, and molybdenum).

A large number of different stages of ionization are involved which are important for different phases in the fusion reactor. Most important are the highly ionized stages, since these are encountered when the fusion machine operates at peak energies. The presence of specific highly ionized spectra indicates the temperatures achieved, so that they may in a sense be considered as "built-in thermometers." However, the lower stages of ionization are also important for studies of the preheating stage and for the interaction of the decaying plasma with the walls of the vessel.

Several different experimental techniques have been applied at NBS to obtain data for the *lower* stages of ionization. For the investigation of *higher* ionization stages, the laboratory investment increases enormously since large amounts of energy are needed to produce the very hot plasmas in which the atoms have lost many of their outer electrons. Fortunately, as the experimental situation becomes less attractive, many of the theoretical difficulties for calculating atomic radiation properties decrease drastically since the atomic systems become less and less complex. Indeed, many calculations have been performed for highly ionized atomic systems.

The experimental as well as theoretical data for these calculations are as a rule still rather inaccurate, and their uncertainties are very hard to estimate. It is, therefore, very desirable to tie the experimental and theoretical data together to have an independent check on their accuracy and consistency. Such a connection was found by Wiese and his coworkers, who established several years ago that systematic trends exist for these atomic properties along isoelectronic sequences. These findings are now put to good use to tie the theoretical and experimental data together and to provide reliable new data for the highly ionized species encountered in fusion machines by interpolating between existing data. About 100 of such systematic trends have been now firmly established, usually with a mutual consistency in the data of

about 30 percent, which is quite acceptable for the needs of fusion studies.

This work has, however, just barely scratched the surface. To be useful to the diagnosis of fusion plasmas, at least 10 times the amount of data are needed because of the large amount of elements in different stages of ionization involved. Furthermore, as indicated by the elements given as examples, the needs of fusion researchers are often for rather "exotic" elements. Thus, much more work is necessary to improve the situation significantly and to provide new additional systematic trends from which further data may be interpolated. But it should be well worth the effort, since this may mean a more accurate diagnosis of fusion plasmas.

Thermonuclear fusion is generally considered to be the ultimate long range answer to this Nation's energy needs. Fusion power has three distinct advantages over other systems of producing power: (a) deuterium, the source of the fuel, is obtainable at little cost from the world's oceans; (b) at the projected rate of our energy needs, the fuel is practically inexhaustible; and (c) in contrast to fission reactors, fusion reactors contain no significant radiation hazards, and there is no danger of "runaway" explosions which is a strong "plus factor" from the environmental viewpoint.

With fossil fuels being depleted at a tremendous rate and fuel shortages already being felt throughout the Nation, the motivation to produce new sources of energy is indeed very strong. It easily justifies the large investments undertaken by several leading industrial nations, in spite of the enormous difficulties and risks involved in achieving the goal of fusion power.

Fusion research has existed for almost 20 years, and after periods of near despair and pessimism, recent

*continued on page 199*

# STANDARD GASES FOR AUTOMOTIVE EMISSIONS ANALYSIS NOW AVAILABLE

Accurate measurement is one of the major problems involved in compliance with and enforcement of the Clean Air Act. NBS has just issued the first of a series of standard reference gases that will provide auto manufacturers, government agencies, and manufacturers of specialty gases with a common measurement base.[1] The gases can be used as standards of reference in the calibration of instrumentation employed in vehicle emissions analysis.

Referring to the measurement problem, Theodore G. Eckman of General Motors Proving Ground stated, "For some years now, the automobile industry has been required to meet various emission standards set forth by the legislative branches of Federal and State governments with no assurance that individual company master calibrating standards are accurate and agree with government test facilities' master calibrating standards."

In July 1972, NBS and the Environmental Protection Agency (EPA) sponsored a meeting with auto manufacturers and specialty gas manufacturers to discuss problems in measuring low concentrations of gases in narrow ranges. At this meeting it was agreed that NBS, under EPA sponsorship, should develop calibration standards for four different gas mixtures in various concentrations. Two sets of standards are now available—propane in air and carbon dioxide in nitrogen. Work is continuing on two more—carbon monoxide in nitrogen and nitric oxide in nitrogen; these standards should become available by the end of the year.

Standard Reference Materials (SRM's) 1665 through 1669 consist of propane in air at concentrations of 3, 10, 50, 100, and 500 ppm by volume. Mixtures of carbon dioxide in nitrogen at concentrations of 1, 7.5, and 15 mole percent are designated SRM's 1673-1675.

The materials for SRM's 1665-1669 and 1673-1675 were compounded by an experienced gas supplier adhering to rigid specifications prepared by NBS. The individual cylinders of each SRM were analyzed by gas chromatography to assure compliance with specifications and to establish a relative value for the concentration with an imprecision of less than 0.3 percent of either the propane or the carbon dioxide in the sample. The absolute concentration of the substance was determined by relating this precise concentration to the concentration of propane or carbon dioxide contained in a set of absolute standards.

These standard reference gases should not be considered as daily working standards; rather, they are "primary" standards, to be used to calibrate the daily working standards obtained from commercial sources and to be used by gas manufacturers to calibrate the commercial standards they produce.

[1] Available from the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C. 20234.

# OPTICAL RADIATION NEWS

## SPECTROPHOTOMETRY PROGRAM INITIATED

In December of 1972, a study of the role in spectrophotometry of the NBS Institute for Basic Standards (IBS) was completed, and in late April 1973, the program proposed in the report of that study was approved. This month's Optical Radiation News will be devoted to describing the philosophy behind this program, the program itself, and the current and future activities in spectrophotometry of the Optical Radiation Section.

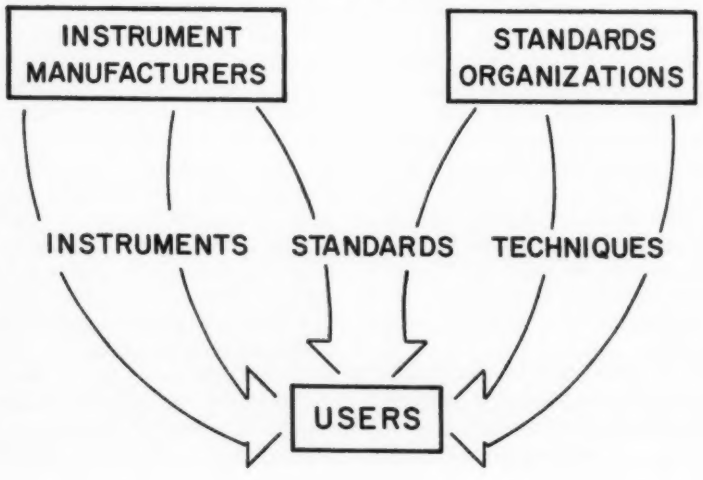
## THE PHILOSOPHY BEHIND THE PROGRAM

Spectrophotometry, as used here, involves three elements: (1) a well-defined input flux of radiation which strikes, (2) a medium with which the flux interacts, and (3) a well-defined output flux resulting from the interaction. The medium can range in its nature from a specimen of material to a complex optical instrument. The object of a spectrophotometric measurement is to determine as a function of wavelength the ratio of the power in the outgoing flux to that in the incoming flux in order to determine certain optical properties of the medium such as transmittance, reflectance, scattering, and fluorescence. These optical properties may in turn be correlated with other properties of the medium such as its structure, quality, or chemical composition. Spectrophotometric measurements are widely used for quality control, sensing for automated production, medical and chemical analysis, specification of color and appearance, and a variety of other purposes. They provide data essential to activities which account for from one-fifth to one-third of the gross national product in the United States. Furthermore, realizing a realistic level of improvement in these measurements can potentially provide benefits in terms of increased productivity, decreased waste, better health, decreased damage from pollution, etc., with tangible values alone amounting to several billion dollars annually. In light of this, the spectrophotometry program in IBS is being strengthened in order to assure that it will be possible to realize these benefits, and even to provide a stimulus for their realization.

Since the measurements involve ratios of fluxes, the work of the standards laboratory does not involve maintaining a basic unit such as the meter, second, volt, or kilogram. However, the measurements depend upon many parameters such as solid angles of acceptance, wavelength, area of sample, and direction of incident and exitant fluxes. As a result, the measurements are complicated in conception and practice; and much careful work needs to be done in determining which choice of parameters should be used in a given application, defining the measurements, and specifying standard techniques for making the measurements.

The structure of the spectrophotometric portion of the national measurement system, illustrated in the diagram, is basically quite simple. The instruments, which usually represent a considerable investment to the user,

*The Primary Structure of the Spectrophotometric Measurement System.*



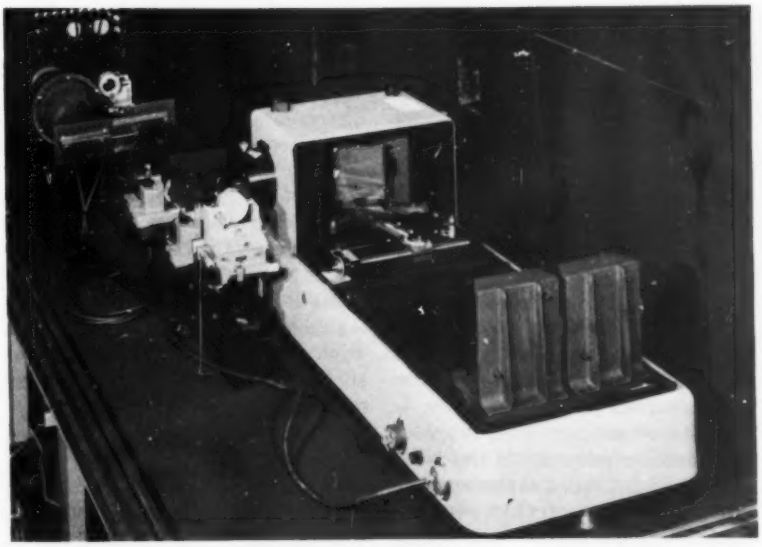
are sold directly by the instrument manufacturer or by a technical sales organization one step removed from the manufacturer. As a result, the instrument manufacturers tend to feel a strong and direct responsibility for the proper operation of the measurement system. The instrument manufacturers are often also suppliers of secondary standards for testing and calibrating the instruments. For the "paper standards," or procedures to use for a specific application, the user generally relies on a standards organization, which may be a general one such as ASTM or ANSI, or which may be highly specific such as a committee in a trade organization or technical society. Within this structure, it is felt that we can most readily determine the need for improvements by being sensitive to the problems and activities of the users, while most of the improvements can be most efficiently brought about by working principally with the instrument manufacturers and standards organizations. The view of the measurement system determines the general direction the spectrophotometry program is taking.

## THE PROGRAM ITSELF

Fundamental to any good program in spectrophotometry is the ability to make highly accurate spectrophotometric measurements. This requires instrumentation which is very precise and which can be analyzed readily for systematic errors, and the ability to measure peripheral properties, such as indices of reflection and aperture areas, which are related to each type of measurement. In order to meet present and future needs, approximately half of the effort of our spectrophotometry program for the first 5 years will be directed toward developing reference instrumentation. This effort has been divided into five areas, with the principal responsibility assigned to one of the five professional members of our spectrophotometry group, as follows: Specular transmittance and reflectance—Mr. Kenneth L. Eckerle; Bidirectional reflectance and transmittance—Dr. Jack J. Hsia; Hemispherical measurements—Mr. Robert J. Bruening; Far infrared measurements—Mr. Victor R. Weidner; and Photoluminescent measurements—Dr. William H. Venable, Jr. The major effort in these areas will be made in approximately the order given above, with the initial efforts all to be completed by 1978. The first three categories will include measurements over the wavelength range from 0.2 to 2 micrometers. The far infrared work will include a number of different measurement geometries and will cover the wavelength range from 2 to 50 micrometers. The photoluminescent work will initially be directed toward surface and dry powder fluorescence as required for specification and quality control of fluorescent paints, plastics, and detergents.

As our measurement capability becomes developed in each area, specific efforts to improve the national measurement system will be undertaken. This will be done principally in three ways. First, we will work with the many committees of trade organizations, scientific societies, and national and international standardization organizations which produce written procedural standards and specifications. The Optical Radiation Section will assist in coordinating these efforts and, when needed, will supply measurement and consulting services in order to obtain the maximum compatibility in definition, measurement techniques, and measurement scale between different parts of the scientific community. Second, we will investigate the causes of systematic measurement errors and will develop means of reducing them. The results of this work are to be passed on to the instrument manufacturers through publications and the sale or lease of packaged experiments (part of this section's Measurement Assurance Program—MAP) designed to detect and measure the extent of syste-

*The monochromator and measurement section of the IBS high accuracy transmittance spectrophotometer.*



matic errors in the instruments they produce. Improvement in the commercial instruments in general use is essential if improved accuracy is to be available to the average user. Finally, secondary standards such as filters and reflectors must be provided. The very general standards which we now supply directly will soon be supplied through the Office of Standard Reference Materials in the Institute for Materials Research (IMR) for economy and more rapid service. In the case of other standards, we will concentrate on supplying primary calibrations to commercial and governmental secondary standards laboratories and will provide ways to trace the values assigned by these laboratories to NBS measurements.

Up until the very recent past, the spectrophotometry program at NBS was oriented towards providing "service measurements," i.e., measurements, the end purpose of which was not the improvement of the measurement system, were done for a fee upon request. Under the new program, we will tend to restrict service measurements to those which we feel will enable us to gain information and insight which can be applied towards improving the measurement system. Such measurements might be those of a very new type, those in which there is a difference between measurements which cannot be resolved, and those which cannot be obtained from other laboratories. In the latter regard, we would like to be able to suggest where given measurements can be obtained commercially. We will be contacting the laboratories about which we know and would welcome information concerning services available from any laboratory offering spectrophotometric measurements.

An important part of the program will be documentation of the NBS activities in spectrophotometry. When appropriate, technical publications will be made in technical and trade journals. More detailed accounts of the technical work will appear in the Optical Radiation Section's series of NBS Technical Notes 594, and announcements of meetings, activities, and policy decisions will appear from time to time in future editions of *DIMENSIONS / NBS*.

(It should be made clear at this point that another section in NBS, the Analytical Coordination Chemistry Section, of IMR, under the direction of Dr. Oscar Menis, also has a strong program in spectrophotometry. The IMR program is principally directed towards the measurements made in analytical chemistry and toward providing chemical reference materials, whereas the IBS program is directed toward the remaining uses of spectrophotometric measurements and the fundamental optical problems of the measurements. There is close cooperation between the two sections, particularly in the regions of overlapping interest such as the performance of spectrophotometers used in analytical chemistry.)

## CURRENT AND FUTURE ACTIVITIES

One of our most urgent areas of effort is to lay the groundwork for defining what is to be measured, since a measurement can be no more accurate than its definition. The ground rules for the definition and description of the measurements which will be made in the spectrophotometry program will be published in a Technical Note in the 594 series. This Technical Note, scheduled to be completed in the fall of 1973, will serve as a reference for definitions given in future Technical Notes on specific measurements, thereby allowing the future work to be presented more succinctly.

A reference specular transmittance instrument had already been built under the direction of Dr. Klaus D. Mielenz before the present program was planned, as described in NBS Technical Note 729, "Design, Construction, and Testing of a New High Accuracy Spectrophotometer" by K. D. Mielenz and K. L. Eckerle. In its present form, the instrument can measure appropriate samples to an accuracy of $10^{-4}$ transmittance units over the wavelength range 350 to 800 nanometers. Work currently under way to expand the wavelength range to extend from 200 to 2000 nanometers should be completed within a year. A specular reflectance attachment for this instrument which will cover all angles of incidence from grazing to within 3° of normal is being assembled, and a filter holder in which glass filters can be temperature controlled to within 0.1 kelvin is nearing completion. The instrument is being fully automated with the use of a MIDAS system ("MIDAS—Modular Interactive Data Acquisition System—Description and Specification" by C. H. Popenoe and M. S. Campbell, NBS Technical Note currently being prepared). Projects for the near future in this area include updating the standard filters for transmittance (NBS 212.141a) and the color standards for spectrophotometer-tristimulus integrator systems (SRM 2101 through 2105), and careful evaluation of the $V(\lambda)$ filters used in photometric calibrations. This instrument will be available in approximately 1 year for primary calibrations of specular transmittance and reflectance standards. Inquiries from interested secondary standards laboratories will be welcomed.

Our laboratory has been participating for some time in the Collaborative Reference Program on ASTM 60° gloss, an intercomparison sponsored by the Manufacturer's Council for Color and Appearance (MCCA), and is currently acting in concert with the National Research Council Laboratories in Canada to provide a reference value

for these measurements. The present NBS goniophotometer, on which these measurements are made, has been carefully characterized and is being automated. The documentation of calibration procedures for gloss standards, an analysis of the errors allowed under the present ASTM and other international standards, and a description of the modified goniophotometer are to be published upon the completion of the work. The publication will also include proposals for and descriptions of our initial MAP for gloss measurements.

A reference instrument for highly accurate general bidirectional reflectance and transmittance measurements is in the planning stage. This instrument is scheduled to be put into operation in approximately 2 years.

In the area of diffuse measurements, our first efforts are being directed towards establishing a well documented present position, consolidating what is available from the past. Scheduled for the winter of 1973 is a Technical Note in the 594 series treating these measurements with emphasis on the Vitrolite Glass standards and the realization of the perfectly reflecting diffuser. The report will include corrections for certain recently discovered systematic errors in the measured values of these reflectors and quantitative data on the translucence and uniformity of Vitrolite. Data which has been obtained in the past on certain other secondary standards such as $BaSO_4$, MgO, $CaCO_3$, and $MgCO_3$ will be included to provide a convenient cross reference between reflectance scales which have been based on these materials.

In another facet of hemispherical measurements, measurements of dental ceramic opacity standards have recently been completed for the American Dental Association, and work will soon begin on opacity standards for paper reflectance in cooperation with the Institute for Applied Technology of NBS and the Institute for Paper Chemistry. Included in this work are corrections for errors related to the spreading of the light in the translucent opacity standards.

Until recently, the section had an active program of service measurements in far infrared reflectance using a borrowed instrument which is now unavailable. The planning for a reference instrument for the far infrared is scheduled to begin in mid 1974 and, until this instrument is completed, our work will be limited to very routine transmittance measurements. In the meantime, however, we are participating in Infrared Information Symposia (IRIS) work on infrared filters and working in an advisory capacity with the U.S. Public Health Service Testing and Certification Laboratory regarding safety lenses for welding and laser work and with the U.S. Army countersurveillance laboratory.

The first stages of work toward reference instrumentation for photoluminescence has begun. A wide dynamic range photon counting system is being constructed for use with moderate to very low light levels, and the initial design has been completed for a calibratable attenuator for the range $10^{-3}$ to $10^{-7}$ transmittance. This attenuator, the principal purpose of which is to provide a means of relating the rather strong incident radiation to the much weaker outgoing radiation in photoluminescent measurements, will also be used in primary calibrations for high density standards which are used in nondestructive food inspection and will provide a check for attenuation measurements used in radiometry and photometry.

Other projects include development of reference and portable field test instrumentation for retroreflective materials, a review in cooperation with MCCA of the consistency of calibration of white diffuse reflectance standards which are sold commercially, and research on improved secondary standards for diffuse reflectance. Although the initial intensive study upon which the program was based has been completed, and although there has been a great deal of formal input from CORM and other groups to aid in determining the overall direction the spectrophotometry program will take, the success of the program depends upon our working very directly with those who are faced with measurement problems and are responsible for having them solved. For this reason we welcome detailed discussions concerning specific types of spectrophotometric measurements with those who are involved. We also would appreciate more general comments and suggestions concerning this program. The person in the Optical Radiation Section to contact in this regard is the spectrophotometry group leader:

Dr. William H. Venable
A317 Metrology Building
National Bureau of Standards
Washington, D.C. 20234
Telephone 301/921-2453

## DETECTOR STUDIES

The fifth NBS Technical Note (No. 594-5) in the Optical Radiation Measurement Series has gone to press.[1] The title is "Stability and Temperature Characteristics of Some Silicon and Selenium Photodetectors" and the authors are K. Mohan, A. R. Schaefer, and E. F. Zalewski. The Technical Note describes a study of the suitability of certain detectors for goniometric measurements of visible radiant flux. The detectors were operated in the photovoltaic nonbiased mode, and were characterized for stability of output over approximately 20 hours, fatigue or light memory effects over short periods of time, and temperature dependence of output.

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Order No. C13.46:594-5. Price 35 cents.

# HIGHLIGHTS

## NEW BROADCAST SERVICE CARRIES PACIFIC STORM AND SKYLAB INFORMATION

NBS Radio Station WWV (Boulder, Colo.) is offering new services to its users.

Storm information is now broadcast for the eastern Pacific. It is similar to broadcasts for the entire Pacific already on WWVH, Kauai, Hawaii. The new service was initiated because WWVH is not received reliably on the U.S. West Coast. It parallels information about Atlantic storms broadcast on WWV, and provides data on storm location and movement.

WWV and WWVH are also announcing Skylab experiments. Both stations now broadcast information about current and upcoming experiments using the Apollo Telescope Mount to alert ground observers so they can coordinate their activities.

## EVALUATION OF STONE PRESERVATIVES

The National Park Service, concerned about the preservation of historic buildings and monuments like the Lincoln Memorial in Washington, D.C., has requested NBS assistance in evaluating so-called stone preservatives. Eight tons of building stone and a wide range of commercial stone preservatives will be used in weathering tests. A special chamber has been designed and is being constructed at the Illinois Institute for Technology Research. Within this chamber, stone will be exposed to a variety of corrosive conditions. The initial phase of the project, the evaluation of the preservatives, is expected to take 3 years.

## NATIONAL FIRE DATA SYSTEM

Auerbach Associates, under contract to NBS, has completed design of a National Fire Data System (NFDS). Efforts toward implementing the system at NBS has begun. NFDS staff will collect fire data from statewide fire data collection groups. The data will concern the frequency, severity, and nature of fire. Fire data will also be collected from insurance companies and hospitals with the assistance of the Consumer Product Safety Commission. These data will be stored in a computer and analysis of the data will be done by NFDS staff located at NBS. From these data, priorities for programs in fire research and safety will be established, and specific problems identified on which work is required. These data will also assist government, public, and private agencies in developing standards and codes for life safety and will assist the fire services in the management of their resources.

## STEEL PILINGS TO BE EXAMINED

Corrosion behavior of protected carbon and low alloy steel piling in seawater is being investigated in a joint research effort by NBS, the U.S. Army Corps of Engineers, and the U.S. Naval Civil Engineering Laboratory, with support from the American Iron and Steel Institute. Ninety-three "H" and pipe specimens, 35-feet long, were embedded in the Atlantic Ocean floor off the coast of Dam Neck, Va., more than 5 years ago. The results of this study, which will take about 15 years to complete, will demonstrate which of the systems tested is best for protecting steel piles in seawater.

Many types of protective methods are included in the investigation: coating systems (coal-tar epoxy, hot-dip zinc, flamesprayed aluminum and zinc, zinc-rich paints, epoxies, etc.), cathodic protection by zinc and aluminum sacrificial anodes, and combinations of coatings and cathodic protection.

During the last week in April, the first group of 31 piles was removed for measurement and study. These had been exposed to the sea for over 5 years. The other two groups will be removed after being exposed for 10 and 15 years, respectively.

## COLOR IMAGING IN SCANNING ELECTRON MICROSCOPY

It takes optics fine I we'en
To see what cannot be seen
(Coleridge)

Electron images need not be colorless—especially when the use of color provides information not easily available from black and white photographs. The NBS scanning electron microscope (SEM) was recently modified so that selected area electron channelling patterns can now be obtained. These patterns provide crystallographic information from approximately the top 100 Å of the specimen. Weak contrast bands and lines appear. If the signal is differentiated, the lines are enhanced but all the grey levels in the bands are washed out. Combining the two images in color provides a result in which the delicate shadings in the bands and the lines are seen in nearly optimum contrast. The band shadings are needed for determining the crystal orientation; the lines will be used in assessing the strain state of the region responsible for the pattern.

## AUTO INDUSTRY AIDED WITH SOLID STATE TECHNOLOGY

Semiconductor components and transducers are finding increasing use in motor vehicles. They are being used in safety devices and emission controls, such as electronic ignition systems, fuel injection systems, projected seat

belt interlock systems, and engine performance computers. Because of these applications, the automobile industry has expressed concern about the availability of reliable semiconductor components and transducers at reasonable cost. NBS engineers and automotive personnel at central research facilities have been assessing problems in device reliability, interchangeability, and performance as well as the possible role of NBS in the resolution of the problems.

### NEW CRYOGENIC MATERIAL PROPERTIES PROGRAM

For the first time in the evolution of electrical power equipment, superconductivity, a unique and exceptional technology, is available to the electric machine designer.

Because the operating temperature of superconductors is near that of liquid helium (4K), the Advanced Research Projects Agency of the DoD (ARPA) has contracted with the Cryogenics Division of NBS to study and measure the thermal and mechanical properties at 4K of structural materials. The planned 3-year program has been funded for the first year at $700,000, two-thirds of which will be subcontracted to other laboratories.

Manufacturers of superconducting generators and motors have been rather seriously hampered by insufficient and, in some cases, total lack of relevant data for proper design to insure successful long-time operation. Special emphasis will be placed on fracture properties; fracture toughness, fatigue, and fatigue crack growth rate data at 4K, currently nonexistant, are urgently needed.

### THREE EXPERIMENTS ABOARD SKYLAB SUPPORTED BY NBS CALIBRATION SYSTEMS

The three experiments are (1) a Naval Research Laboratory (NRL) "spectroheliograph," which takes pictures of the sun's surface in a series of far-vacuum-ultraviolet wavelengths; (2) an NRL extreme-ultraviolet slit spectrometer, taking photographic spectra of small well-defined regions of the solar surface; and (3) a Harvard College Observatory photoelectric scanning spectrometer, examining the chromosphere and lower corona.

NBS has played an innovative role in these experiments by developing new spectral radiance calibration techniques in a region of the spectrum where no standard sources were previously available. The NASA scientific groups have depended upon backup from the NBS calibration facility to keep flight preparations on schedule.

## Fabric Flammability Tests to be Studied

Test methods for determining fabric flammability hazards will be investigated under a 6-month $22,369 grant awarded by NBS to the University of Maryland's Department of Textiles and Consumer Economics.

Dr. Ira Block, principal investigator, together with co-investigators Dr. Betty Smith and Dr. Steven Spivak, will study the physical and chemical phenomena that occur during the burning of fabrics and those parameters which influence the results of standard flammability tests methods.

The first part of the grant-funded study is intended to find out more about what happens while a fabric is burning. It will focus on such phenomena as: the extent to which the fiber is consumed during burning, the fiber's heat of combustion, the formation of heat and drips, and their influence on the heat being generated.

With this information, the investigators will then study the design aspects of current standard flammability test methods. The test procedures, test specimens, the effect of fabric weight and construction, and melt-drip phenomena will be analyzed. The effects of such parameters as ignition methods, burner design, humidity, rate of air flow, configuration of the test sample, conditioning procedures, correlation between fabric weight and burning rate, and the mass distribution of drips will be examined.

The study will result in suggestions for optimizing test methods used to determine the flammability hazards of fabrics. The importance of such tests would be hard to overestimate, and the goal of this study is to increase their reliability.

### ATOMIC DATA *continued*

experiments seem to have put the final goal within sight. The two most critical factors needed to attain fusion are a temperature of nearly 100 million K (comparable to temperatures in the interior of stars) and a containment time (i.e., density × time) of about $10^{14}$ cm·s (Lawson criterion). Just a few years ago, fusion machines were a factor of 10,000 or more away from these conditions, but the gap has been closed considerably within the last years to roughly a factor of 100. Encouraged by the good understanding of present fusion plasmas made possible by the availability of adequate atomic data such as supplied by NBS, present reactors are being scaled up in size.

It is anticipated that the feasibility of fusion will be demonstrated before this decade is out.



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